NASA SBIR/STTR Technologies

T6.02-9986 - Improved Forecasting of Solar Particle Events and their Effects on Space Electronics

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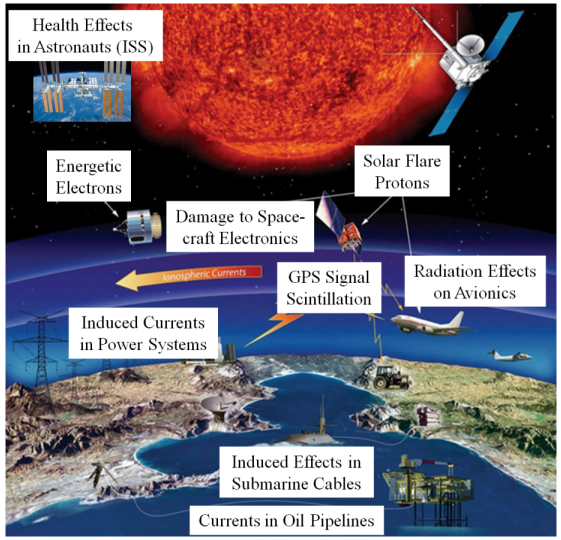
Identification and Significance of Innovation

Energetic particles from Solar Particle Events (SPEs) associated with flares/coronal mass ejections constitute a dynamic radiation environment that may adversely affect space missions, and high-altitude and terrestrial systems. It is crucial to forecast SPEs and their effects on systems to plan NASA mission-related tasks and adopt risk mitigation strategies for personnel and equipment. The proposed effort will develop a comprehensive modeling capability, comprising individual modules to address different aspects of the overall problem, for complete event-to-effects analyses. INNOVATIONS: (1) Integrated modeling software with state-of-the-art modules to address issues from SPE forecasting to transport of particles through heliosphere and geomagnetic/atmospheric interactions, to calculating induced single-event effects (SEEs) in electronics; (2) Flexibility to link with other radiation effects calculation codes; (3) Use of empirical/physics-based models and observations for high fidelity; (4) Emphasis on transitioning software to operational use. Estimated TRL: Begin-4, End-5



Estimated TRL at beginning and end of contract: (Begin: 4 End: 5)

Technical Objectives and Work Plan

-Technical Objective: Develop a capability to accurately forecast SPEs (both probability of event and all-clear scenarios) and the impact of SPE-generated energetic particles on electronics. We will utilize an integrated approach including high-fidelity computational software and available observations, to achieve this objective. WORK PLAN: PHASE I RESULTS: (1) Demonstrated suitability of component codes (MAG4, PATH, Geant4) for their respective tasks using prior solar event; (2) Developed interfaces for data transfer between codes; (3) Developed Python-based controller script for automated execution and data transfer; (4) Demonstrated overall event-to-effects calculation flow using the 28-Sep-2012 event; & (5) Developed concept of final software product for NASA. PHASE II TASKS: (1) SPE4 Framework: Develop client-server architecture for continuous (24x7) execution of codes (MAG4, PATH, Geant4, CREME96); (2) MAG4: Develop improved forecast of CME parameters and correlation between CME speed and flare parameters; (3) PATH: Add capability to use 1.5D transport code and cross-field diffusion, and better integration with MAG4; (4) Geant4: Incorporate Tsyganenko magnetic field model, include solar heavy ion transport, and optimize particle spectrum sampling; (5) CREME96: Integrate with Geant4 results, calculate resulting SEEs; (6) Verify robustness of overall simulation flow.

NASA Applications

Improved forecasting of SPEs and their effects is aligned with NASA's Living With a Star program, the Human Research Roadmap, and OCT TA06, specifically, Radiation (Space Weather Prediction and Protection Systems). The developed SPE4 software will support mission operational planning (e.g., at SRAG/JSC) by forecasting the occurrence and all-clear periods of SPEs, to plan extra-vehicular activities for astronauts at the ISS, and planned temporary shutdown of systems to avoid catastrophic failure.

Non-NASA Applications

A predictive capability for SPE-induced radiation and resulting effects in electronics can help mission/equipment managers schedule tasks and adopt risk mitigation strategies. Directly relevant to DoD agencies and commercial entities with space-based or high-altitude assets (e.g., satellites), navigation/GPS, radio communications, electrical power transmission systems, oil pipelines.

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